Docket No. 2001-067-TAP

BARCODE SINGLE LASER SCANNER TARGETING

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates generally to an apparatus for calibrating an apparatus for retrieving objects from an array of storage cells.

2. Background of the Invention:

Storage library systems are capable of storing and rapidly retrieving large quantities of information stored on storage media cartridges. Such storage library systems often use robotic mechanisms to improve the speed of information retrieval and the reliability of maintaining the storage library cartridge inventory. These robotic mechanisms typically comprise a hand mechanism positioned on a movable arm. To retrieve information, the robotic arm is moved to position the hand near the inventory location of a desired media cartridge. The hand is then activated to grip the desired cartridge and remove it from the library inventory location. The robotic arm with the hand gripping the cartridge then moves to an appropriate position to further process the cartridge. In this manner, the robotic hand manipulates the cartridge for access to information stored on the cartridge.

However, in order to grip the cartridge, the position of the robotic arm with respect to the cartridge

within the library must be determined. Positional accuracy of the robotic arm and any devices attached thereto affects both the repeatability of an operation as well as the ability of the robotic arm to accurately perform the particular task required of it. There are many different arm calibration arrangements known in the art, and many of these entail the use of some sort of sensor to determine the position of the robotic arm.

A common method of calibrating the position of the robotic arm gripper mechanism is to use a vision system to orient the robotic arm with respect to one or more baseline targets located in the work space. Often these vision systems are located underneath or above the robotic arm and are oriented at an angle relative to the robotic arm. These vision systems are located at an angle so that a target on the work space can be imaged, and then a target located on a part of the robotic arm that is extended into the field of view of the vision system is imaged. The two images are compared and the position of the robotic arm is adjusted such that the target on the robotic arm is aligned with the target on the work piece when extended.

However, orienting the vision system at an angle causes the inclusion of the vision system with the robotic arm to take up a large amount of space. Thus, a significant portion of the space within the storage library system is unusable for placing storage cells. This is due to the fact that if, for example, the vision system is located below the robotic arm, an amount of space equal to the height or thickness of the angled

vision system at the bottom of the storage retrieval system cannot be accessed by the robotic arm since the vision system comes into contact with the floor of the storage library system before the robotic arm. Thus, the robotic arm is prevented from going low enough within the storage library system to engage and retrieve an object stored in a storage cell located within the thickness of the angled vision system from the floor of the storage library system.

However, as the need to store more and more data increases and the price paid for space also increases, the amount of money necessary to store data is increased. Thus, the wasted space within a library storage system becomes more and more intolerable. Therefore, there is a need for a calibration system that requires less space than current systems and that allows for a denser concentration of storage cells within a storage library system.

SUMMARY OF THE INVENTION

The present invention provides a robot apparatus and a barcode scanner to be used for collecting positional data parallel to the scan direction in, for example, a library storage system. In one embodiment, the robotic apparatus includes a barcode scanner with a scan path and an attenuation surface within the scanner scan path. The barcode scanner scans the target while the robotic apparatus is moved in a direction parallel with the scan path. Positional data is collected in conjunction with the readability limits of the barcode target. The central position of the target in a parallel direction to the scan path is determined based on the readability of the barcode target and the correlating positional data. The barcode scanner can also scan the target while the robotic apparatus is moved in a direction perpendicular with the scan path. Positional data is collected in conjunction with the readability limits of the barcode target. The central position of the target in a perpendicular direction to the scan path is determined based on the readability of the barcode scanner and the correlating positional data.

density of storage cells **130** in a particular library, the camera vision system **360** of the present invention is implemented as a barcode laser scanner rather than a line scan camera as was typical in the prior art. Barcode scanners are commonly available products used in systems, such as, for example, check out scanners for super markets and are well known in the art. A barcode scanner is smaller than a line scan camera. Therefore, less space is needed to accommodate the barcode scanner. Thus, more room is available for storage cells, thereby increasing the storage density of a storage library.

With reference now to **Figure 6**, a diagram of a barcode scanning apparatus suitable for use with a cartridge retrieval system is depicted in accordance with the present invention. Barcode scan apparatus **602** may be implemented as the camera vision system **360** in **Figure 3**. Barcode scan apparatus **602** includes a barcode laser or charge coupled device (CCD) scan engine **604**, and an aperture **606**. Barcode scan apparatus **602** is smaller than the line scan camera used in the prior art. Therefore, a smaller amount of space is necessary to accommodate the camera vision system **360**. Thus, more space in the library storage system may be devoted to storage cells, thereby increasing the storage density of the library storage system.

Barcode scan cameras or engines have not been used for calibration purposes in the prior art because the output from barcode scanners is merely the decoded value of the bar code scanned by the barcode scanner. Therefore, barcode scanners do not provide any pixel

data. Furthermore, the scan width of the laser scanner beam from the barcode laser scanner is not controlled. Therefore, the proper calibration measurements cannot be made. However, to overcome these shortcomings, the present invention incorporates an aperture **606** between the barcode scan engine **604** and a target barcode **608**. The aperture opening **610** must be smaller than the scan width of the barcode scan engine **604**, thus ensuring that the scan width **612** is uniform. The flexture is a mechanical apparatus within the barcode scan engine that controls the movement of the mirror that reflects the laser light across an area. Since the flexture is mechanical, the movement of the robotic arm **110** during the calibration procedure will affect the flexture causing the scan width **612** to be variable. The aperture **608** is situated to reduce the scan width generated by the movement of the flexture such that the scan width is uniform. This produces a non-variable scan-width giving a controlled end of scan.

To determine the center of the target in the direction parallel to the scan path, the robotic arm **110** is moved in the direction of scan path until the target **608** first becomes readable. This position is recorded through the use of a positional encoding device. The robotic arm **110** continues to move in the same direction until the target is no longer readable by the barcode scanner apparatus **602**. This position is also recorded. The center of the target in the scan path direction is then the half distance position between these two positions.